
CLAIMS

[Claim(s)]
[Claim 1] It is the piezoresistance mold 3 shaft acceleration sensor characterized by being 3 shaft acceleration sensor which detects acceleration with a piezoresistance object, and allotting the field of the greater part of the piezoresistance object on the flexible section by which both ends were connected to the outer frame section and the mass section, and piezo resistor pair spacing for the X-axis and Y-axes differing from piezo resistor pair spacing for the Z-axes.
[Claim 2] The piezoresistance mold 3 shaft acceleration sensor according to claim 1 characterized by piezo resistor pair spacing for the Z-axes being larger than X and piezo resistor pair spacing for Y-axes, and arranging some piezoresistance objects [at least] for the Z-axes on the outer frame section and the mass section.
[Claim 3] A piezoresistance mold 3 shaft acceleration sensor given in claims 1 and 2 to which the difference of piezo resistor pair spacing for the Z-axes, X, or piezo resistor pair spacing for Y-axes is characterized by being 1.2 or less more than 0.4L to die-length L of a piezoresistance object.
[Claim 4] The piezoresistance mold 3 shaft acceleration sensor according to claim 1 characterized by piezo resistor pair spacing for the Z-axes being smaller than X and piezo resistor pair spacing for Y-axes, and arranging the piezoresistance object for the Z-axes on the flexible section.
[Claim 5] A piezoresistance mold 3 shaft acceleration sensor given in claims 1 and 4 to which the difference of piezo resistor pair spacing for the Z-axes, X, or piezo resistor pair spacing for Y-axes is characterized by being below 1.8L more than 1.0L to die-length L of a piezoresistance object.

[Translation done.]

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3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the semi-conductor acceleration sensor for acceleration detection used for a toy, an automobile, the aircraft, a personal digital assistant device, etc.
[0002]
[Description of the Prior Art] The structure of the conventional piezoresistance mold 3 shaft acceleration sensor is explained to a detail. The sectional view which met drawing 7 in the top view of an acceleration sensor at the A-A' line of drawing 7 is shown in drawing 8 . The outer frame section 3 allotted so that the mass section 1 and it which consist of the heavy-gage part of a silicon single crystal substrate (henceforth Si single crystal substrate) might be surrounded. The flexible section 21 of the shape of two pairs which consist of the thin-walled part of Si single crystal substrate which connects this mass section 1 and the outer frame section 3 of beams which intersects perpendicularly mutually, 21', The two directions (X and Y) of [on 22 and 22' and this flexible section] which intersect perpendicularly and this flexible section 21, 21', 22 -- 22 -- ' -- being perpendicular -- a direction -- (-- Z --) -- corresponding -- as -- preparing -- having had -- each -- a shaft -- plurality -- piezo one -- a resistor -- a group -- 51 -- 51 -- ' -- 52 -- 52 -- ' -- 61 -- 61 -- ' -- 62 -- 62 -- ' -- 71 -- 71 -- ' -- 72 -- 72 -- ' -- from -- constituting -- having . Moreover, the flexible section 21, 21', and by preparing a through hole in drawing 7 at a thin-walled part, as the sign 4 showed, 22 and 22' is made into the beam configuration, is easy to deform, and has structure suitable for high sensitivity-ization.
[0003] The flexible section 21 when the central mass section 1 displaces the detection principle of acceleration in response to the force proportional to acceleration, 21', 22 -- 22 -- ' -- bending -- flexiblity -- the section -- forming -- having had -

- piezo one — a resistor — a group — 51 — 51 — ' — 52 — 52 — ' — 61 — 61 — ' — 62 — 62 — ' — 71 — 71 — ' — 72 — 72 — ' — a change in resistance — ****** — detecting — things — three — shaft orientations — acceleration — detecting — a thing — it is . Here The flexible section 21, four piezoresistive elements 51 on 21', 51', 52 and 52' the acceleration of X shaft orientations Moreover, other four piezoresistive elements 71, 71', 72 and 72' — the acceleration of Z shaft orientations perpendicular to a component side — detecting — moreover, the flexible sections 22 and 22 — four upper piezoresistive elements 61, 61', and '62, 62' so that the acceleration of Y shaft orientations which intersect perpendicularly with X shaft orientations may be detected Connection of the piezoresistive element of each four shafts is carried out, respectively so that a bridge circuit may be constituted independently. In the X-axis, 71, 71', and 72 and 72' make [in / for 51, 51', and 52 and 52' / 61, 61' and 62 and 62' and the Z-axis] a piezo resistor pair in a Y-axis to a piezo resistor pair, a call, and this appearance, respectively. Moreover, X and a Y-axis have the same arrangement of an output detection principle, the connection approach, and a piezoresistance object, and since it can change for the shaft of another side, respectively, as long as there is no especially notice of X and a Y-axis, suppose henceforth that it is written as the X-axis.

[0004] Arrangement of the piezoresistance object in the conventional 3 shaft acceleration sensor is explained. As shown in drawing 9 , it had become the structure whose one end of the piezo resistor pair for the X-axes and the piezo resistor pair for the Z-axes corresponds with the boundary of the flexible section and the outer frame section, and the boundary of the flexible section and the mass section. When the flexible section bends in response to acceleration, in order to carry out stress concentration of this to the part the outer frame section in the flexible section, and near the mass section, it is because the maximum sensor output is obtained.

[0005] When the piezoresistance object is arranged like drawing 9 , generally it is known that there is relation to the sensibility (output to acceleration 1G and driver voltage 1V) of the X-axis and the Z-axis as shown in drawing 10 . When the acceleration of 1G is applied to X shaft orientations, the bending moment which joins the flexible section is expressed with the distance (referred to as s1) from the flexible section 21, 21', and the flat surface that passes along 22 and 22' to the center of gravity of the mass section 1, and the product of the mass (referred to as m) of the mass section. Therefore, when the thickness of the mass section changes, since the bending moment is proportional to s1 and m, the secondary sensibility of the X-axis changes functionally. On the other hand, when the acceleration of 1G is applied to Z shaft orientations, the bending moment which joins the flexible section is expressed with the product of the die length (referred to as s2) of the flexible section, and the mass m of the mass section. Therefore, when the thickness of the mass section changes, since the bending moment is proportional only to m, the primary sensibility of the Z-axis changes functionally.

[0006] What is necessary is just to set thickness of the mass section to about 800 micrometers, in order to abolish the output difference of the X-axis and the Z-axis so that drawing 10 may show. However, since there is a problem from which it not only becomes high cost, but about 800-micrometer Si single crystal substrate serves as a special order, and time for delivery becomes unstable since the thickness of Si single crystal substrate used with a semi-conductor etc. is as in use as 625 micrometers 525 micrometers, a desirable approach does not perform output adjustment with the thickness of the mass section.

[0007]

[Problem(s) to be Solved by the Invention] In arrangement of the piezoresistance object of the conventional acceleration sensor, the output of the Z-axis will become large as compared with the output of the X-axis. When the output difference between shafts is large, it is necessary to prepare the amplifier with which output amplification factors differ for every shaft, and there is a fault which becomes cost quantity.

[0008] It is possible to change the high impurity concentration of the piezo resistor group of the Z-axis and other groups, to change a piezo property, to lower the output of the Z-axis, and to make the output of the X-axis and a Y-axis equivalent. However, when forming a piezoresistance object, only the Z-axis needs to drive in an impurity independently, and it becomes the cost quantity by the increase of a process. Moreover, there is a problem that the temperature characteristics of the piezoresistance object for the X-axes and the piezoresistance object for the Z-axes will differ.

[0009] Although the output of the Z-axis can be lowered also by carrying out the parallel displacement of the piezo resistor pair to the flexible section die-length direction, without changing piezo resistor pair spacing for the Z-axes, there is a problem on which offset voltage (output of the Z-axis in the condition that acceleration has not joined each shaft), and other shafts sensibility (output of the Z-axis when acceleration joins other shafts) get worse.

[0010] Although it is also possible to change the configuration of the piezoresistance object of the Z-axis and to lower the output of the Z-axis, since it becomes difficult for the resistance of a piezoresistance object to change and to take bridge balance, as for all piezoresistance objects, it is desirable that it is isomorphism-like.

[0011] So, in this invention, the output difference of three shafts of X, Y, and Z is small, the resistance and the temperature characteristic of a piezoresistance object of three shafts are the same, and it aims at offering 3 shaft acceleration sensor with a cheap manufacturing cost with a small thin shape.

[0012]

[Means for Solving the Problem] The piezoresistance mold 3 shaft acceleration sensor of this invention is 3 shaft acceleration sensor which detects the acceleration of the direction of a flat surface, and a perpendicular direction with a piezoresistance object, and the greater part of the piezoresistance object is arranged on the flexible section by which both ends were connected to the outer frame section and the mass section, and it is characterized by piezo resistor pair spacing for the X-axis and Y-axes differing from piezo resistor pair spacing for the Z-axes.

[0013] the thing of the sensor by which the piezoresistance mold 3 shaft acceleration sensor of this invention detects the acceleration of the direction of a flat surface, and vertical acceleration — saying — the X-axis and the Z-axis — it is — although it has the detection device of sensor [which has the detection device of only a Y-axis and the Z-axis] and X and Y, and Z3 shaft, the sensor only using the X-axis, the Z-axis or a Y-axis, and the Z-axis is also contained.

[0014] In order to obtain an output to the maximum extent, arrangement of a piezo resistor pair was formed so that it might

be made in agreement with the edge of the flexible section in which one end of a piezoresistance object carries out stress concentration also to three shafts on the flexible section. However, with this structure, since the output of the Z-axis becomes large as compared with the output of the X-axis, a piezoresistance object is arranged so that piezo resistor pair spacing for the Z-axes may differ to piezo resistor pair spacing for the X-axes, the output level of the X-axis and a Y-axis is maintained, and the output difference of the X-axis and the Z-axis is made small by lowering the output level of the Z-axis. Piezo resistor pair spacing said here is a pitch to the flexible section die-length direction of the piezoresistance object of the pair in each shaft formed on the flexible section.

[0015] The piezoresistance mold 3 shaft acceleration sensor of this invention has piezo resistor pair spacing for the Z-axes larger than piezo resistor pair spacing for the X-axes, and it is desirable to arrange some piezoresistance objects [at least] for the Z-axes on the outer frame section and the mass section.

[0016] Piezo resistor pair spacing for the Z-axes is larger than piezo resistor pair spacing for the X-axes, and some piezoresistance objects [at least] for the Z-axes are arranged on the outer frame section and the mass section. By arranging some piezoresistance objects on a flexible outside, this makes a piezoresistance object generate an insensible field, and lowers the sensibility of a piezoresistance object.

[0017] The piezoresistance mold 3 shaft acceleration sensor of this invention is larger than piezo resistor pair spacing for the X-axes in piezo resistor pair spacing for the Z-axes, and it is desirable for the difference of piezo resistor pair spacing for the Z-axes and piezo resistor pair spacing for the X-axes to be below 1.2L more than 0.4L to die-length L of the longitudinal direction of a piezoresistance object. It is more desirable to make the difference of this spacing below into 1.0L more than 0.6L.

[0018] The piezoresistance mold 3 shaft acceleration sensor of this invention has piezo resistor pair spacing for the Z-axes smaller than spacing of the piezo resistor pair for the X-axes, and it is desirable to arrange the piezoresistance object for the Z-axes on the flexible section.

[0019] Piezo resistor pair spacing for the Z-axes is smaller than piezo resistor pair spacing for the X-axes, the piezoresistance object for the Z-axes is arranged on the flexible section, and one end of the piezoresistance object for the Z-axes has the boundary of the flexible section and the outer frame section or the boundary of the flexible section and the mass section, and distance. In order that the piezoresistance object for the X-axes may obtain an output to the maximum extent, to one end of a piezoresistance object being allotted to the connection boundary section with the outer frame section and the mass section which carry out stress concentration, the piezoresistance object for the Z-axes is that contribution of a stress concentration field allots little location, and lowers the sensibility of the piezoresistance object for the Z-axes.

[0020] The piezoresistance mold 3 shaft acceleration sensor of this invention is smaller than piezo resistor pair spacing for the X-axes in piezo resistor pair spacing for the Z-axes, and it is desirable for the difference of piezo resistor pair spacing for the Z-axes and piezo resistor pair spacing for the X-axes to be below 1.8L more than 1.0L to die-length L of the longitudinal direction of a piezoresistance object. It is more desirable to make the difference of this spacing below into 1.6L more than 1.2L.

[0021] The piezoresistance mold 3 shaft acceleration sensor of this invention is produced through the following main processes. The process which forms a piezo resistor group in Si single crystal substrate. A piezoresistance object is produced by the ion implantation method by using boron as an impurity at Si single crystal substrate. It is decided with the mask pattern of the photo mask with which a configuration uses the location of a piezo resistor group for patterning, and is made for spacing of a piezo resistor pair of the X-axis on the flexible section and the Z-axis to differ. The process which forms the protective coat which protects a piezo resistor group, and forms the contact hole for making it flow through a piezo resistor group and aluminum wiring by wet etching etc. The piezo resistor group on the flexible section is each the process which forms aluminum wiring so that a bridge circuit may be constituted three shaft. The process which carries out dry etching of the Si single crystal substrate from a front rear face so that the flexible section may serve as a thin beam configuration. The process which cuts Si single crystal substrate and obtains a piezoresistance mold 3 shaft acceleration sensor component. A piezoresistance mold 3 shaft acceleration sensor is obtained through the assembly process which puts a piezoresistance mold 3 shaft acceleration sensor component into a package, and performs wiring etc. In addition, on these specifications, it writes the piezoresistance mold 3 shaft acceleration sensor [a piezoresistance mold 3 shaft acceleration sensor component].

[0022]

[Embodiment of the Invention] The example of the piezoresistance mold 3 shaft acceleration sensor of this invention is explained using drawing 1 and 2. Drawing 1 R> 1 is the top view of the piezoresistance mold 3 shaft acceleration sensor of this invention, and drawing 2 is a partial expansion top view showing arrangement of the piezoresistance object of the X-axis allotted on the flexible section, and the Z-axis.

[0023] the acceleration sensor of this example -- 500 micrometers and width of face were set to 100 micrometers, and thickness of 7 micrometers, the mass section, and the outer frame section was set [the die length of a piezoresistance object / the die length of 110 micrometers and the flexible section] to 550 micrometers for thickness. The piezoresistance object carried out conditioning of the boron which is an impurity to Si single crystal so that it might become with 2x1018 atoms/cm3 with surface high impurity concentration. One end of the piezoresistance object for the X-axes was made in agreement with a flexible section edge, and has been arranged. The difference of the X-axis and piezo resistor pair spacing for the Z-axes was changed in the 0.2L pitch from 0.2L to 2.4L to die-length L of the longitudinal direction of a piezoresistance object. Those of a configuration without a difference were also conventionally produced for the comparison, and the power ratio of the X-axis and the Z-axis was measured. Since the piezo resistor pair for the Z-axes is arranged to the bisector perpendicular to the die-length direction of the flexible section at the symmetry, piezoresistance object 71for the Z-axes ' and a part of 72 become 71' and the structure of drawing 2 where a part of 72' is allotted on the mass section at the outer frame section.

[0024] The power ratio (Z/X) of the X-axis and the Z-axis is shown in drawing 3 . Since the difference of piezo resistor pair spacing and piezo resistor pair spacing for the Z-axes of the power ratio of structure was 0 conventionally which was put into the comparison, a power ratio is 1.5. The output of the Z-axis falls as the difference of Z-axis piezo resistor pair spacing and X-axis piezo resistor pair spacing becomes large, and if the output difference of the X-axis and the Z-axis of the difference is lost by about 0.8 L and it enlarges a difference further, the output of the Z-axis will have become lower than the X-axis. From this thing, the power ratio of the X-axis and the Z-axis can be set to about 1 by carrying out a difference near the 0.8L.
[0025] Other examples of this invention are explained using drawing 4 and 5. Drawing 4 is the top view of a piezoresistance mold 3 shaft acceleration sensor, and drawing 5 is a partial expansion top view showing arrangement of the piezoresistance object of the X-axis allotted on the flexible section, and the Z-axis.
[0026] the acceleration sensor of this example — 500 micrometers and width of face were set to 100 micrometers, and thickness of 7 micrometers, the mass section, and the outer frame section was set [the die length of a piezoresistance object / the die length of 110 micrometers and the flexible section] to 550 micrometers for thickness. The piezoresistance object carried out conditioning of the boron which is an impurity to Si single crystal so that it might become with 2x1018 atoms/cm3 with surface high impurity concentration. One end of the piezoresistance object for the X-axes was made in agreement with a flexible section edge, and has been arranged. The difference of the X-axis and piezo resistor pair spacing for the Z-axes was changed in the 0.2L pitch from 0.2L to 2.4L to die-length L of the longitudinal direction of a piezoresistance object. Those of a configuration without a difference were also conventionally produced for the comparison, and the power ratio of the X-axis and the Z-axis was measured. The piezo resistor pair for the Z-axes is arranged to the bisector perpendicular to the die-length direction of the flexible section at the symmetry, and the piezoresistance objects 71 and 72 for the Z-axes serve as structure of drawing 5 allotted on the flexible section.
[0027] The power ratio (Z/X) of the X-axis and the Z-axis is shown in drawing 6 . The power ratio of structure is 1.5 conventionally which was put into the comparison. The output of the Z-axis falls as the difference of piezo resistor pair spacing for the Z-axes and piezo resistor pair spacing for the X-axes becomes large, and if the output difference of the X-axis and the Z-axis of the difference is lost by about 1.4 L and it enlarges a difference further, the output of the Z-axis will have become lower than the X-axis. From this thing, the power ratio of the X-axis and the Z-axis can be set to about 1 by carrying out a difference near the 1.4L.
[0028] The piezoresistance mold 3 shaft acceleration sensor of this invention was able to make small the output difference of the X-axis and the Z-axis which had 50% to the output of the X-axis conventionally as compared with the conventional piezoresistance mold 3 shaft acceleration sensor. In the difference of the X-axis and piezo resistor pair spacing for the Z-axes, die-length L of the longitudinal direction of a piezoresistance object is received especially. More than 0.6L in the range below 1.0L It was larger than piezo resistor pair spacing for the X-axes in piezo resistor pair spacing for the Z-axes, and the output difference of the X-axis and the Z-axis has been improved to 20% or less by making piezo resistor pair spacing for the Z-axes smaller than piezo resistor pair spacing for the X-axes in the range below 1.6L more than 1.2L.
[0029]
[Effect of the Invention] As explained above, by arranging a piezoresistance object so that piezo resistor pair spacing for the X-axes may differ from piezo resistor pair spacing for the Z-axes, the output of the Z-axis was able to be lowered and the output difference of three shafts was able to be made 20% or less. Since the resistance and the temperature characteristic of a piezoresistance object became the same, and it was not necessary to prepare amplifier for every shaft, the small and cheap piezoresistance mold 3 shaft acceleration sensor could be offered.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The top view of the piezoresistance mold 3 shaft acceleration sensor of this invention
[Drawing 2] The partial expansion top view of the piezoresistance mold 3 shaft acceleration sensor of this invention
[Drawing 3] The graph which shows the power ratio of the X-axis of the piezoresistance mold 3 shaft acceleration sensor of this invention, and the Z-axis
[Drawing 4] The top view of other piezoresistance mold 3 shaft acceleration sensors of this invention
[Drawing 5] The partial expansion top view of other piezoresistance mold 3 shaft acceleration sensors of this invention
[Drawing 6] The graph which shows the power ratio of the X-axis of the piezoresistance mold 3 shaft acceleration sensor of this invention, and the Z-axis

[Drawing 7] The top view of the conventional piezoresistance mold 3 shaft acceleration sensor
[Drawing 8] The A-A' sectional view of the conventional piezoresistance mold 3 shaft acceleration sensor
[Drawing 9] The partial expansion top view of the conventional piezoresistance mold 3 shaft acceleration sensor
[Drawing 10] The graph which shows the relation of the sensibility of the mass section thickness of the conventional acceleration sensor, the X-axis, and the Z-axis

[Description of Notations]

1 The mass section, 21 21' 22 22' The flexible section, 3 The outer frame section, 4 A through hole, 51 51' 52 52' The piezo resistor group of the X-axis, 61 61' 62 62' The piezo resistor group of a Y-axis, 71 71' 72 72' Piezo resistor group of the Z-axis.

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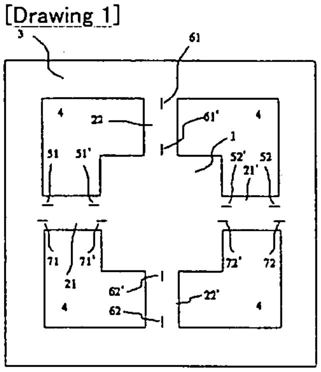
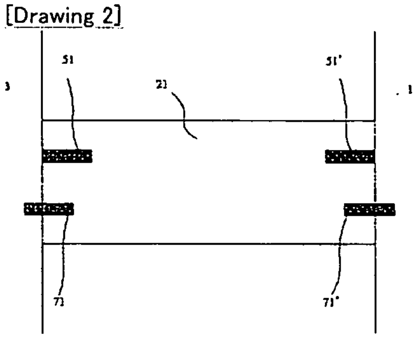
DRAWINGS

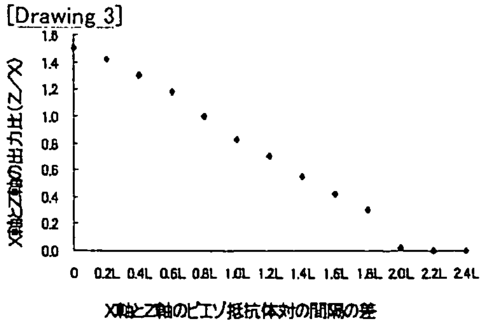
[Drawing 1]



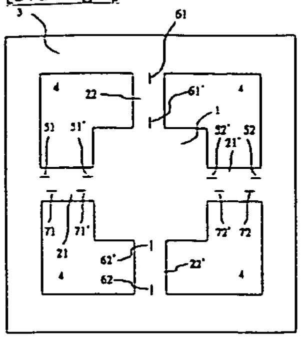
[Drawing 2]



[Drawing 3]



[Drawing 4]



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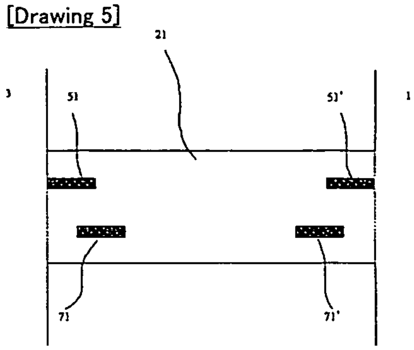
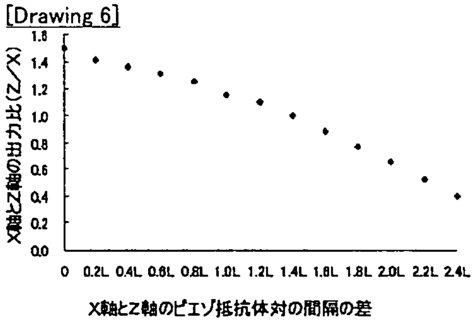
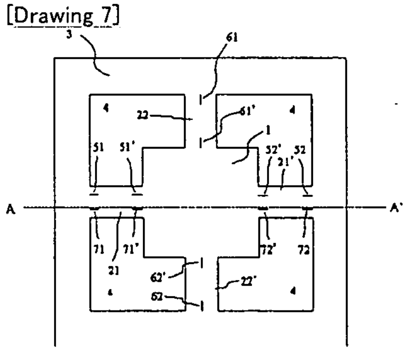


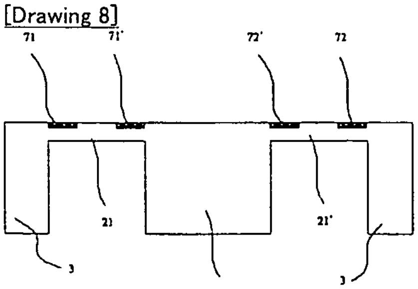
[Drawing 6]



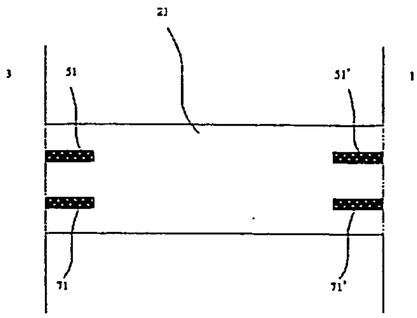
[Drawing 7]



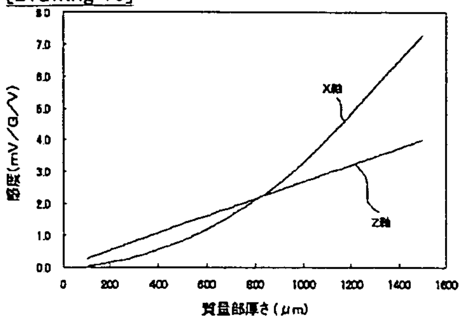
[Drawing 8]



[Drawing 9]



[Drawing 10]



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